APPLICATION OF MULTIPLE ATTRIBUTE DECISION MAKING TO THE OST PEER REVIEW PROGRAM

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INTRODUCTION AND EXECUTIVE SUMMARY

For the last several years, the Office of Science and Technology (OST) of the U.S. Department of Energy (DOE) has used the services of the American Society of Mechanical Engineers (ASME) and the Institute for Regulatory Science (RSI) to peer review various projects and technologies that OST supports. During the initial phases of the peer review program, it became clear that the number of projects was too large for the program to review every one of them annually or even periodically. In conjunction with these activities, a study was initiated to evaluate all projects supported by OST and identify those that needed peer review. The objective of the study was to develop a logical process to screen all projects; eliminate those that did not need to be peer reviewed; and prioritize those that required peer review. In February 2000, RSI was contacted by the OST Peer Review Coordinator and asked if RSI would be willing to continue the study and bring it to a successful conclusion.

In the initial study—known as Triage—three attributes were used and numeric values were generated for each one of them. The chosen attributes were as follows:

1. Investment up to the date of the review

2. Relevance, as expressed by the potential users of the technology

3. Availability at the time the technology is needed by the users

The first phase of the study performed by RSI consisted of evaluation and possible expansion of the existing process. Included in this phase was the assessment of the Triage process; the evaluation of its general usefulness; the response to informal criticism received during the initial phases; and the enhancement of its attributes. A key issue of concern identified during this phase was the lack of a composite score. This phase was completed in April 2000, and included the description of a Multiple Attribute Decision Making (MADM) technique to generate a composite score. In addition, the report proposed to consider the entire cost—rather than cost up to a given date—as the first attribute. Furthermore, it added an additional attribute if the necessary data were available.

The second phase of the study performed at RSI consisted of the application of MADM to the initial three attributes to generate a single score for a given project. This phase was also completed in April 2000.

The third and final phase of the study is provided in this report, and it applies the expanded model to the updated data for Fiscal Year (FY) 2001. In order to enhance its usefulness, relevant segments of the first two phases of the study have been included in this report.

The first part of this report contains a brief description of the MADM—as reported in the first phase of this study. The second part includes a description of attributes used, and it also describes the application of MADM to these attributes. The third part reports the numerical results for the ranking of the FY 2001 projects.

The application of the methodology described in this report provides OST managers with an approach to screen their respective projects and prioritize them for peer review. Once the process of information collection for the chosen attributes is in place, the computation will be largely automated.

PART I. MULTIPLE ATTRIBUTE DECISION MAKING

MULTIPLE ATTRIBUTE DECISION MAKING

Decision makers often deal with problems that involve multiple, usually conflicting criteria. These problems may range from those affecting common households—such as the purchase of an automobile—to those affecting nations—as the national defense spendings. For example, in purchasing a car the following multiple attributes are usually considered: price; comfort; fuel efficiency; safety; maintenance cost; insurance cost; and depreciation. The U.S. News & World—in its annual edition of "America's Best Colleges"—ranks academic institutions based on: academic reputation; student selectivity; faculty resources; financial resources; graduation rate; and alumni satisfaction (Yoon and Hwang 1995). In the U.S. Army each year, about one in six majors is selected for promotion to lieutenant colonel based on: military education level; civil education level; physical readiness and military bearing; officer qualifications; duty performance; and office potential (Yoon and Hwang 1995). Multiple Attribute Decision Making (MADM) refers to making preference decisions—such as evaluation, prioritization, selection—over the available alternatives that are characterized by multiple, usually conflicting attributes (Hwang and Yoon 1981).

MADM is a branch of Multiple Criteria Decision Making (MCDM), which also includes Multiple Objective Decision Making (MODM) (Hwang and Masud 1979). In contrast to MADM problems, MODM problems involve designing the best alternative given a set of conflicting objectives. For example, automobile manufacturers must design a car that maximizes riding comfort and fuel efficiency, but minimizes production and maintenance costs. The alternatives are created through the design process.

A MADM method is an algorithm that specifies how attribute information is to be used in order to arrive at a choice. There are two major approaches in attribute information processing (Hwang and Yoon 1981):

1. **Non-compensatory models:** These models do not permit tradeoffs between attributes. A disadvantage or unfavorable value in one attribute cannot be offset by an advantage or favorable value in another attribute. The methods which belong to this category—dominance; maximin; maximax; conjunctive constraint; disjunctive constraint; and lexicographic—are credited for their simplicity and should be used when the decision maker has limited knowledge.
2. **Compensatory models:** These models allow for disadvantages in one attribute to be offset by advantages in another attribute. A single number is usually assigned to each multidimensional characterization of a given alternative.

An alternative in MADM is usually described by quantitative and qualitative attributes. There are three types of scales that can be employed for these attributes: ordinal scales; interval scales; and ratio scales (Torgerson 1958; Stevens 1959). An ordinal scale sorts the competing alternatives according to their rank, but provides no information with respect to the relative distances among them. An interval scale provides the distances of the competing alternatives with respect to an arbitrary origin (e.g., Fahrenheit scale, Celsius scale). A ratio scale provides the distances of the competing alternatives with respect to a non-arbitrary origin (e.g., Kelvin scale). Most MADM methods use either ordinal or interval scales. The transformation of a qualitative attribute into an ordinal scale is much easier than into an interval scale. One of the most common methods for converting a qualitative attribute into an interval scale is to utilize the bipolar scale (MacCrimmon 1968). One may choose a 10-point scale and calibrate it giving 10 points to the best value and zero points to the worst value. The midpoint would also be a basis for calibration, because it should be the breakpoint between values that are favorable and values that are unfavorable.

The MADM problems share the following characteristics (Yoon and Hwang 1995):

1. **Alternatives:** A finite number of alternatives are screened; prioritized; selected; or ranked. The term "alternative" is synonymous with "candidate"; "option"; "policy"; and "action".

2. **Multiple Attributes:** Each problem has multiple attributes. A decision maker must generate relevant attributes for each problem setting. The term "attributes" is synonymous with "criteria" and "goals".
3. **Incommensurable Units:** Each attribute may have different units of measure.
4. **Attribute Weights:** Almost all MADM methods require information regarding the relative importance of each attribute, which is usually supplied through an ordinal or cardinal scale. Weights can be assigned directly by the decision maker.
5. **Decision Matrix:** A MADM problem can be concisely expressed in a matrix format, where columns indicate attributes considered in a particular problem, and rows list competing alternatives. Therefore a typical element x_{ij} of the decision matrix indicates the performance rating of the ith alternative (A_i) with respect to the jth attribute (X_j).

A classic piece of advice on MADM was given by Benjamin Franklin (1772) in a letter to Joseph Priestley: "...[M]y way is to divide half a sheet of paper by a line into two columns; writing over the one Pro, and over the other Con. Then, during three or four days consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, for or against the measure. When I have thus got them all together in one view, I endeavor to estimate their respective weights; and where I find two, one on each side that seem equal, I strike them both out. If I find a reason pro equal to some two reasons con, I strike out the three. If I judge some two reasons con, equal to three reasons pro, I strike out the five; and thus proceeding I find at length where the balance lies; and if, after a day or two of further consideration, nothing new that is of importance occurs on either side, I come to a determination accordingly. And, though the weight of the reasons cannot be taken with the precision of algebraic quantities, yet when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, and am less liable to make a rash step, and in fact I have found great advantage from this kind of equation, and what might be called moral or prudential algebra."

In 1988, a significant budget reduction at the University of Wyoming left the Athletic Department approximately \$700,000 short on operating funds compared to its previous budget (Swenson and McMahon 1991). The alternatives capable of realizing the proposed budget cuts included: the elimination of the men's and women's ski programs (A_1); the baseball program (A_2); and the women's golf team (A_3). In order to evaluate these alternatives, the Athletic Department decided to use the following attributes: the number of people directly affected (X_1); money saved by the department (X_2); and miscellaneous (X_3). For X_1, the values were calculated by adding the number of participants and coaches. For X_2, the values represent money saved in the first year after the program is dropped. For X_3, a five-point scale—very high=1, high=2, average=3, low=4, very low=5—was used to account for facility proximity, fan support, past success, and required facility. The decision matrix as indicated in Table 1 is as follows:

Table 1. The decision matrix (Swenson and McMahon, 1991).

Alternatives	Attributes		
	X_1	X_2	X_3
A_1	30	\$174,140	3
A_2	29	\$74,683	4
A_3	12	\$22,496	5

A similar example is presented by Yoon and Hwang (1985) for a manufacturing plant location. Table 2 contains a list of the first applications of the MADM.

Table 2. First applications of the MADM.

Reference	Comments
Davos et al. (1979)	Nuclear facility siting in California.
Keeney (1979)	Evaluates 10 sites for the pumped storage hydroelectric generation facility. Attributes: first year cost; transmission line distance; forest lost; and community lost due to the construction.
Nakayama et al. (1979)	Assesses the residential environment in Kyoto using 12 attributes: proportion of green area; proportion of park area; population density; medical facilities; bad odor; traffic accidents; sulphurous acid gas; soot and smoke; factories; accessibility to downtown; offices of the business affecting public morals; and land price.
Dinkel and Erickson (1978)	Evaluates environmental program effectiveness using: number of serious pollution incidents; number of less serious pollution incidents; number of complaints; comparison of environmental quality; compliance index; and number of non-monitored industries.
Moscarola (1977)	Selection of candidates for business school admission. Attributes: high school average grade; improvement; experience; motivation; and professional interest.
Einhorn and McCoach (1977)	Evaluates player performance in the National Basketball Association. Eight attributes: field goal percentage; free throw percentage; rebounds; assists; steals; personal fouls; points per minute played;and blocked shots. The resulting ranking predicted correctly the NBA all-star team.
Hirschberg (1977)	Graduate students selection policies. A linear regression is robust.
Gros et al. (1976)	Nuclear facility siting in New England. Four attributes: number of units at a given site; cost; population within ten kilometers of a given site; incremental water temperature at peak ambient water temperature period of year.
Litchfield et al. (1976)	Analyses of a hypothetical advanced nuclear waste management system.
Hill and Alterman (1974)	Nuclear facility siting in Israel.
Green and Carmone (1974)	Graduate business students' evaluation of (hypothetical) assistant professors for tenured positions. Uses a regression model with three criteria: research and publication; teaching; and institutional contribution).
Easton (1973)	Compares three evaluation rules—geometric mean; arithmetic mean; and quadratic mean—for the selection of a sales manager.

Table 2. (cont'd.)

Reference	Comments
Ellis and Keeney (1972)	Evaluate two air pollution control strategies for New York City. Attributes: per capita increase in the number of days of remaining lifetime; per capita decrease in the number of days of bed disability per year; per capita annual net costs to low-income residents; per capita annual net costs to other residents; daily sulfur dioxide concentration; total annual net cost to city government; and subjective index of political desirability.
Klee (1971)	Alternatives for wood removal in salvaging the metal from railroad cars. Attributes: capital cost; ability to salvage the wood removed; time needed to develop the process; contribution to air pollution; and operating cost.
Dawes (1971)	University committee admitting Ph.D. students. Attributes: GRE; GPA; and quality of undergraduate school attended.
Klahr (1969)	College admission officers' preferences. Attributes: alumni interview; campus interview; college board score; extracurricular activities; high school grade average; high school recommendation; IQ level; and rank in senior class.
Smith and Greenlaw (1967)	Simulation model for the hiring of company employees.

It has become increasingly more complicated for a decision maker to make the right decision at the right time. To select a candidate to fill a certain position is difficult because there may be many qualified applicants. The sequential procedures of decision making include: the preparatory phase; the screening phase; the evaluating phase; and the selection phase. The preparatory phase includes advertising very specifically for what is desired. The screening phase consists of using various methods to eliminate the unqualified candidates. The evaluating phase includes reviewing the qualified candidates. Finally, the committee members may come with a recommendation to the manager, or they may provide a list of pros and cons of each eligible candidate and let the manager decide. Mathematical solutions have been provided for the evaluation and selection phases. Probably the most commonly used evaluation techniques are ranking; rating; scoring; and utility function—all of which indicate preferences with respect to a group of candidates. The ordinal approach—which involves the ranking of candidates—has been investigated among others by Souder (1973a; 1973b); Cook and Seiford (1978; 1982a); and Franz et al. (1981). The cardinal approach—which involves the scoring of candidates—has been investigated among others by Eckenrode (1965); Dean and Nishry (1965); Fishburn (1966); Souder (1972); Minnehan (1973); Keeney and Kirkwood (1975); Dyer and Miles (1976); and Hwang and Yoon (1981).

The advantage of the ordinal approach is that the assignment technique can be used quite easily. The Borda score (i.e., the sum of the committee members scores) used in the ordinal approach is very popular. An example is the weekly poll made by the American Press or United Press International for the top 20 college basketball U.S. teams. The advantage of the cardinal approach is that it may take into account the distances among the different candidates, and the relative closeness of the top candidate, with respect to the ideal candidate.

The entropy method

Entropy has become an important concept in physics as well as in the social sciences (Capocelli and De Luca 1973; Nijkamp 1977). Additionally, entropy has a useful meaning in information theory where it is used as a measure of the expected information content of a given message. In the information theory, entropy is also used as a measure for the uncertainty of a discrete probability density function (Shannon and Weaver 1949; Jaynes 1957):

$$S(p_1,...,p_n) = -k \sum_{i=1}^{n} p_i \cdot \ln(p_i)$$

Because this definition is similar to the one used in statistical mechanics, this measure of uncertainty is labeled entropy. When all probabilities are equal, the entropy reaches its maximum.

The decision matrix for a set of alternatives contains a certain amount of information. Entropy can therefore be used as a tool in attribute evaluation (Zeleny 1974; Nijkamp 1977). Entropy is particularly useful to investigate contrasts among data sets. An attribute is not very useful when all alternatives have similar values for that attribute. Furthermore, if all values are the same, that attribute should be eliminated.

The entropy of each attribute is:

$$E_j = -\frac{1}{\ln(m)} \sum_{i=1}^{m} p_{ij} \cdot \ln(p_{ij})$$

where:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad , x_{ij} > 0 \quad \forall\, i, j$$

and x_{ij} is the numerical outcome of the ith alternative with respect to the jth attribute.

The degree of diversification of the information provided by the outcomes of attribute j is:

$$d_j = 1 - E_j$$

If the decision maker does not prefer one attribute over another, the Principle of Insufficient Reason (Starr and Greenwood 1977) suggests that each one should be equally preferred. Then the best weight set that can be used is:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

A review of other weight assessment techniques may be found in Eckenrode (1965); Hobbs (1980); Stillwell et al. (1981); Hwang and Yoon (1981); and Voogd (1983).

Technique for order preference by similarity to ideal solution

A MADM problem with m alternatives that are evaluated by n attributes may be visualized as a set of m points in an n-dimensional space. There is an ideal level of attributes for the alternative of choice (Coombs 1958; Coombs 1964). The decision maker's utility decreases monotonically when an alternative moves away from this ideal—or utopia—point (Yu 1985). Because the ideal is dependent on the current economic and technical limits and constraints, a perceived ideal is utilized to implement the choice rationale. The positive-ideal solution is defined as the hypothetical alternative with the supremum—for maximum attributes—and infimum—for minimum attributes—ratings for the m alternatives. The negative-ideal solution is defined as the hypothetical alternative with the supremum—for minimum attributes—and infimum—for maximum attributes—ratings for the m alternatives. The Technique for Order Preference by Similarity to Ideal Solution (Yoon 1980; Yoon and Hwang 1980; Hwang and Yoon 1981; Zeleny 1982; Yoon 1987; Hall 1989; Hwang et al. 1993; Yoon and Hwang 1995), is based on the fact that the selected alternative should have the shortest distance with respect to the positive-ideal solution, and the longest distance with respect to the negative-ideal solution (Dasarathy 1976).

The normalized decision matrix is computed based upon the decision matrix. The vector normalization is used to compute the normalized ratings (r_{ij}) based upon the numerical outcome of the ith alternative with respect to the jth attribute (x_{ij}):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad , \quad i = 1,\ldots,m \quad j = 1,\ldots,n$$

The weighted normalized decision matrix is computed based upon the normalized decision matrix and the weights vector, where w_j is the weight of the jth attribute:

$$v_{ij} = w_j \cdot r_{ij} \quad , \quad i = 1,\ldots,m \quad j = 1,\ldots,n$$

The positive-ideal solution A^+, and the negative-ideal solution A^-, are defined with respect to the weighted normalized decision matrix as follows:

$$A^+ = \{v_1^+,\ldots,v_n^+\} = \{(\max_i v_{ij} \,|\, j \in J_1), (\min_i v_{ij} \,|\, j \in J_2) \,|\, i = 1,\ldots,m\}$$

$$A^- = \{v_1^-,\ldots,v_n^-\} = \{(\min_i v_{ij} \,|\, j \in J_1), (\max_i v_{ij} \,|\, j \in J_2) \,|\, i = 1,\ldots,m\}$$

where J_1 is the set of maximum attributes, and J_2 is the set of minimum attributes. The positive-ideal solution identifies the most preferable alternative, and the negative-ideal solution identifies the least preferable alternative. The separation of each alternative from the positive-ideal solution is S_i^+ :

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad , \quad i = 1,\ldots m$$

Similarly, the separation of each alternative from the negative-ideal solution is S_i^- :

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad , \quad i = 1,...m$$

The similarity of each alternative to the positive-ideal solution (i.e., the relative closeness of each alternative with respect to the positive-ideal solution) is S_i :

$$S_i = \frac{S_i^-}{(S_i^+ + S_i^-)} \quad , \quad i = 1,...,m$$

The alternatives should be ranked in accordance to their similarities. The ranking process can be expressed through the indifference curves defined as:

$$s = \frac{S^-}{(S^+ + S^-)}$$

The indifference curve equation can be rewritten as:

$$s \cdot S^+ - (1 - s) \cdot S^- = 0$$

This equation indicates that the indifference curve is a variation of a hyperbola where the difference between two weighted distances (i.e., s and (1-s))—with respect to two focal points (i.e., the positive-ideal solution and the negative-ideal solution)—is zero. A decision maker is expected to give equal preference to all alternatives located on the same indifference curve.

PART II. APPLICATION OF MADM TO OST PEER REVIEW PROCESS

APPLICATION OF MADM TO OST PEER REVIEW PROCESS

A detailed presentation of the application of MADM to the OST Peer Review Process is presented by Sorin Straja (2000a). For clarity, the salient features are presented below.

In order to provide OST with a tool for the decision making process, the scores of the attributes should be used to generate a composite index for a given project using the MADM technique. Not all relevant data are available; therefore, a hierarchical approach is proposed.

The **first hierarchical level** uses the following attributes:

1. Cost to date (Maximum)
2. Total cost (Maximum)
3. Timing (Maximum)
4. Relevance (Maximum)
5. Availability (Maximum)

The **second hierarchical level** may be used when additional data are available. The second hierarchical level uses the following attributes:

1. Cost to date (Maximum)
2. Total cost (Maximum)
3. Timing (Maximum)
4. Relevance (Maximum)
5. Availability (Maximum)
6. Benefit margin (Maximum or minimum)

For the first hierarchical level, the attributes are considered as follows:

1. Total cost is the estimated cost of the project for its whole lifespan, as opposed to the Cost to date which includes only the amount already spent. The Investment attribute of Wilkey et al. (1999) corresponds to the Cost to date.

2. If the best moment to review a project is when x% of the Total cost has been spent, then the Timing attribute is computed as follows:

$$t = \frac{100}{x} \cdot \frac{Cost\ to\ Date}{Total\ Cost} \qquad if\ \frac{Cost\ to\ Date}{Total\ Cost} < \frac{x}{100}$$

$$t = \frac{100}{100-x} \cdot (1 - \frac{Cost\ to\ Date}{Total\ Cost}) \qquad if\ \frac{Cost\ to\ Date}{Total\ Cost} \geq \frac{x}{100}$$

For this application, x has been selected as 30%.

3. The Relevance attribute is computed as follows (Wilkey et al., 1999) :

$$R = [\frac{3N_1 + 2N_2 + N_3}{3N_{1FA} + 2N_{2FA} + N_{3FA}}] \cdot 100$$

where:

N_1 = the number of needs addressed by the project and having priority 1
N_2 = the number of needs addressed by the project and having priority 2
N_3 = the number of needs addressed by the project and having priority 3
N_{1FA} = the number of needs having priority 1
N_{2FA} = the number of needs having priority 2
N_{3FA} = the number of needs having priority 3

1. In order to cover all cases, the Availability attribute of Wilkey et al. (1999) is expanded as follows:

Score = 5   available on or before earliest needs date
          = 4   available after earliest but on or before latest needs date
          = 3   indeterminate, only needs dates known
          = 2   indeterminate, only technology availability known
          = 1   indeterminate, needs dates and technology availability known
          = 0   available after the latest needs date

It should be mentioned that both the Total cost and the Cost to date are difficult to obtain for a given project.

As a minimum, the projects should be ranked using the first hierarchical level. For those projects that have additional information available, the ranking may be refined using the second hierarchical level. Adding attribute 6 may be beneficial, but the data are likely to be difficult to obtain. The benefit margin may also be used to accept or reject new projects.

PART III. RESULTS FOR FY 2001

RESULTS FOR FY 2001

The results presented consist of the third and final report of this screening project. The first report (Straja 2000a) described the methodology. The second report (Straja 2000b) contained the application of the methodology to the data which existed at that time. This part includes the results of the data for FY 2001.

The raw data were received by e-mail as EXCEL files and are listed in the Appendix. For each Focus Area, the Composite Score was computed based upon the values provided for Cost to date; Total cost; Timing; Relevance; and Availability. The projects are ranked according to the Composite Score. The Composite Score is always between 0 and 1. A project has a Composite Score of 1 when it is ranked as the best project by each attribute separately. Conversely, a project has a Composite Score of 0 when it is ranked as the worst project by each attribute separately. Peer review records indicate that several projects have already been peer-reviewed by ASME/RSI. Tables 3-7 list the results separately for each Focus Area: Decommissioning and Decontamination (DD); Transuranics and Mixed Waste (TMW); Subsurface Contaminants (SC); Tanks (T); and Nuclear Material (NM). Table 8 lists the results for all Focus Areas.

An assessment of the composite score provides some interesting insights—both on the applied methodology and the ranking of various projects. Because both past expenditure and total expected expenditure are used, projects with high past expenditures do not always have a high ranking. Thus, the ranking is influenced by these two expenditures and the timing attribute. A similar situation exists for the Relevance and Availability attributes where the higher ranking projects in each one of them did not result in higher overall ranking. In fact, the rank of a project is determined simultaneously by all five attributes. The roles played by these attributes are different from one Focus Area to another.

The computation of a Composite Score demonstrated the value of the applied method. Clearly, the decision maker is provided with an additional tool to make the necessary decision. Due to the lack of consideration of the Benefit margin, the results of this effort are of limited value. Accordingly, the decision maker is urged to be cautious in using these results.

Table 3. Decommissioning and Decontamination Focus Area

Rank	OST Technology No.	Technology Title	Cost to Date	Total Projected Cost	Timing	Relevance	Availability	Composite Score
1	2173	Dual-Point Impedance Control for Telerobotics	$664,879.00	$1,200,000.00	0.637	0.565	4	0.666
2	2199	Modular Manipulator for Robotic Applications	$1,521,633.00	$2,500,000.00	0.559	0.348	5	0.546
3	148	Asbestos Pipe-Insulation Removal System	$2,360,743.00	$3,000,000.00	0.304	0.087	4	0.334

Table 4. Transuranics and Mixed Waste Focus Area

Rank	OST Technology No.	Technology Title	Cost to Date	Total Projected Cost	Timing	Relevance	Availability	Composite Score
1	106	Catalytic Chemical Oxidation-Delphi Detox	$14,162,917.00	$20,000,000.00	0.417	0.308	4	0.951
2	1664	Mechanical Systems-Handling Material in CH Processes using HANDSS-55 Systems	$3,466,000.00	$9,500,000.00	0.907	0.075	4	0.317
3	2021	Hydrogen Gas Getters	$1,061,000.00	$3,000,000.00	0.923	0.140	5	0.160
4	2052	Characterization of RH Waste Drums using Multi-Detector Assay System	$1,204,000.00	$2,500,000.00	0.741	0.150	4	0.156
5	2305	Continuous Emissions Monitor for Dioxins	$1,230,657.00	$3,300,000.00	0.896	0.103	4	0.146
6	2170	Surface Acoustic Wave Mercury Vapor Sensor	$2,149,792.00	$3,150,000.00	0.454	0.075	5	0.140
7	2146	Nondestructive Assay of Boxes Containing Transuranic Waste	$1,517,000.00	$1,900,000.00	0.288	0.103	5	0.113
8	2226	Pulsed Gamma Neutron Activation Analysis System for the Assay of RCRA Metals in Mixed Waste	$2,228,672.00	$2,229,000.00	0.000	0.009	5	0.107
9	2053	Characterization of Remote-Handled WasteDrums Using Gamma Spectrometry Combined with Acceptable Knowledge	$409,000.00	$900,000.00	0.779	0.084	4	0.098
10	1564	Compact Resolution Spectrometer	$770,000.00	$1,500,000.00	0.695	0.028	4	0.074
11	2041	Mercury Contamination - Separate and Remove Mercury Using Polymer Filtration	$750,000.00	$1,050,000.00	0.408	0.019	5	0.045

Table 5. Subsurface Contaminants Focus Area

Rank	OST Technology No.	Technology Title	Cost to Date	Total Projected Cost	Timing	Relevancy	Availability	Composite Score
1	2186	Long-term Surface Barriers	$4,000,000.00	$7,000,000.00	0.612	0.500	4	0.998
2	307	In Situ Permeability Measurements with Direct Push Techniques	$368,066.00	$700,000.00	0.677	0.188	5	0.002

Table 6. Tanks Focus Area

Rank	OST Technology No.	Technlogy Title	Cost to Date	Total Projected Cost	Timing	Relevancy	Availability	Composite Score
1	1989	Salt Cake Dissolution	$1,325,000.00	$3,700,000.00	0.917	0.446	5	0.790
2	2967	Chemical Cleaning	$100,000.00	$600,000.00	0.556	0.364	4	0.503
3	2119	Nested Fixed Depth Fluidic Sampler	$2,190,000.00	$3,000,000.00	0.386	0.099	5	0.457
4	2367	Pipe Unplugging	$2,056,000.00	$4,000,000.00	0.694	0.050	4	0.415
5	841	Russian Separations-Cobalt Dicarbollide	$1,229,000.00	$3,629,000.00	0.945	0.124	5	0.357
6	2968	Cesium Removal Using AMP-AN	$700,000.00	$3,200,000.00	0.729	0.124	5	0.260

Table 7. Nuclear Materials Focus Area

Rank	OST No.	Title	Cost to Date	Total Projected Cost	Timing	Relevancy	Availability	Composite Score
1	2343	Porous Crystalline Matrix	$500,000.00	$1,000,000.00	0.714	0.030	1	0.931
2	12	Removal of Plutonium Contamination from Uranium Metal Surface	$0.00	$5,150,000.00	0.000	0.030	2	0.080
3	14	Removal of Plutonium Contamination	$0.00	$2,000,000.00	0.000	0.045	2	0.032
4	7	Advanced Modeling and Experimantal Validation of Complex Nuclear Material Waste Forms of Potential Transportation Concern	$0.00	$1,450,000.00	0.000	0.104	2	0.031
5	13	Decontamination of Uranium Parts Using Laser Ablation	$0.00	$1,916,000.00	0.000	0.030	2	0.030
6	11	Implementation of Moisture Measurement Technology for Nuclear Materials Stabilization	$0.00	$931,000.00	0.000	0.104	2	0.026
7	10	Relative Humidity: A Practical Measurement of Material Moisture Content	$0.00	$1,130,000.00	0.000	0.060	2	0.020
8	15	Verification of Plutonium Removal from Uranium	$0.00	$1,120,000.00	0.000	0.045	2	0.018
9	8	Modeling Gas generation from Radiolysis of Adsorbed Water on Plutonium Dioxide	$0.00	$680,000.00	0.000	0.075	2	0.017
10	9	3CEJ Alpha Radiolysis Studies for U-233 Oxides	$0.00	$501,000.00	0.000	0.075	2	0.016
11	4	Optimal Plutonium Precipitation for Stabilization Feed Preparation	$0.00	$500,000.00	0.000	0.075	2	0.016
12	2	Automatic Packaging of Nuclear Material	$0.00	$750,000.00	0.000	0.030	2	0.011
13	5	Dissolution and Stabilization of Plutonium Using Thermally Unstable Complexants	$0.00	$720,000.00	0.000	0.030	2	0.010
14	3	Plutonium thermal Treatment Furnace Load-out System	$0.00	$634,000.00	0.000	0.015	2	0.008
15	6	Prevention of the Precipitation of Unwanted Solids During Canyon Dissolution	$0.00	$168,000.00	0.000	0.015	2	0.000

Table 8. All Focus Areas

Rank	Focus Area	OST Technology No.	Technology Title	Cost to Date	Total Projected Cost	Timing	Relevance	Availability	Composite Score
1	TMW	106	Catalytic Chemical Oxidation-Delphi Detox	$14,162,917.00	$20,000,000.00	0.417	0.308	4	0.902
2	SC	2186	Long-term Surface Barriers	$4,000,000.00	$7,000,000.00	0.612	0.500	4	0.337
3	TMW	1664	Mechanical Systems - Handling Material in CH Processes using HANDSS-55 Systems	$3,466,000.00	$9,500,000.00	0.907	0.075	4	0.278
4	DD	2173	Dual-Point Impedance Control for Telerobotics	$664,879.00	$1,200,000.00	0.637	0.565	4	0.203
5	T	1989	SaltCake Dissolution	$1,325,000.00	$3,700,000.00	0.917	0.446	5	0.195
6	DD	2199	Modular Manipulator for Robotic Applications	$1,521,633.00	$2,500,000.00	0.559	0.348	5	0.168
7	DD	148	Asbestos Pipe-Insulation Removal System	$2,360,743.00	$3,000,000.00	0.304	0.087	4	0.162
8	T	2119	Nested Fixed Depth Fluidic Sampler	$2,190,000.00	$3,000,000.00	0.386	0.099	5	0.154
9	TMW	2170	Surface Acoustic Wave Mercury Vapor Sensor	$2,149,792.00	$3,150,000.00	0.454	0.075	5	0.151
10	T	2367	Pipe Unplugging	$2,056,000.00	$4,000,000.00	0.694	0.050	4	0.150
11	TMW	2226	Pulsed Gamma Neutron Activation Analysis System for the Assay of RCRA Metals in Mixed Waste	$2,228,672.00	$2,229,000.00	0.000	0.009	5	0.146
12	T	2967	Chemical Cleaning	$100,000.00	$600,000.00	0.556	0.364	4	0.132
13	T	841	Russian Separations-Cobalt Dicarbollide	$1,229,000.00	$3,629,000.00	0.945	0.124	5	0.113
14	TMW	2146	Nondestructive Assay of Boxes Containing Transuranic Waste	$1,517,000.00	$1,900,000.00	0.288	0.103	5	0.109
15	TMW	2305	Continuous Emissions Monitor for Dioxins	$1,230,657.00	$3,300,000.00	0.896	0.103	4	0.106
16	TMW	2052	Characterization of RH Waste Drums using Multi-Detector Assay System	$1,204,000.00	$2,500,000.00	0.741	0.150	4	0.105
17	TMW	2021	Hydrogen Gas Getters	$1,061,000.00	$3,000,000.00	0.923	0.140	5	0.102
18	NM	12	Removal of Plutonium Contamination from Uranium Metal Surface	$0.00	$5,150,000.00	0.000	0.030	2	0.089
19	T	2968	Cesium Removal Using AMP-AN	$700,000.00	$3,200,000.00	0.729	0.124	5	0.087
20	SC	307	In Situ Permeability Measurements with Direct Push Techniques	$368,066.00	$700,000.00	0.677	0.188	5	0.077
21	TMW	1564	Compact Resolution Spectrometer	$770,000.00	$1,500,000.00	0.695	0.028	4	0.057
22	TMW	2041	Mercury Contamination - Separate and Remove Mercury Using Polymer Filtration	$750,000.00	$1,050,000.00	0.408	0.019	5	0.053
23	NM	7	Advanced Modeling and Experimantal Validation of Complex Nuclear Material Waste Forms of Potential Transportation Concern	$0.00	$1,450,000.00	0.000	0.104	2	0.045
24	TMW	2053	Characterization of Remote-Handled Waste Drums Using Gamma Spectrometry Combined with Acceptable Knowledge	$409,000.00	$900,000.00	0.779	0.084	4	0.044
25	NM	11	Implementation of Moisture Measurement Technology for Nuclear Materials Stabilization	$0.00	$931,000.00	0.000	0.104	2	0.041
26	NM	2343	Porous Crystalline Matrix	$500,000.00	$1,000,000.00	0.714	0.030	1	0.037
27	NM	14	Removal of Plutonium Contamination	$0.00	$2,000,000.00	0.000	0.045	2	0.037
28	NM	13	Decontamination of Uranium Parts Using Laser Ablation	$0.00	$1,916,000.00	0.000	0.030	2	0.034
29	NM	8	Modeling Gas generation from Radiolysis of Adsorbed Water on Plutonium Dioxide	$0.00	$680,000.00	0.000	0.075	2	0.028
30	NM	9	3CEJ Alpha Radiolysis Studies for U-233 Oxides	$0.00	$501,000.00	0.000	0.075	2	0.027
31	NM	4	Optimal Plutonium Precipitation for Stabilization Feed Preparation	$0.00	$500,000.00	0.000	0.075	2	0.027
32	NM	10	Relative Humidity: A Practical Measurement of Material Moisture Content	$0.00	$1,130,000.00	0.000	0.060	2	0.027
33	NM	15	Verification of Plutonium Removal from Uranium	$0.00	$1,120,000.00	0.000	0.045	2	0.023
34	NM	2	Automatic Packaging of Nuclear Material	$0.00	$750,000.00	0.000	0.030	2	0.014
35	NM	5	Dissolution and Stabilization of Plutonium Using Thermally Unstable Complexants	$0.00	$720,000.00	0.000	0.030	2	0.014
36	NM	3	Plutonium thermal Treatment Furnace Load-out System	$0.00	$634,000.00	0.000	0.015	2	0.010
37	NM	6	Prevention of the Precipitation of Unwanted Solids During Canyon Dissolution	$0.00	$168,000.00	0.000	0.015	2	0.004

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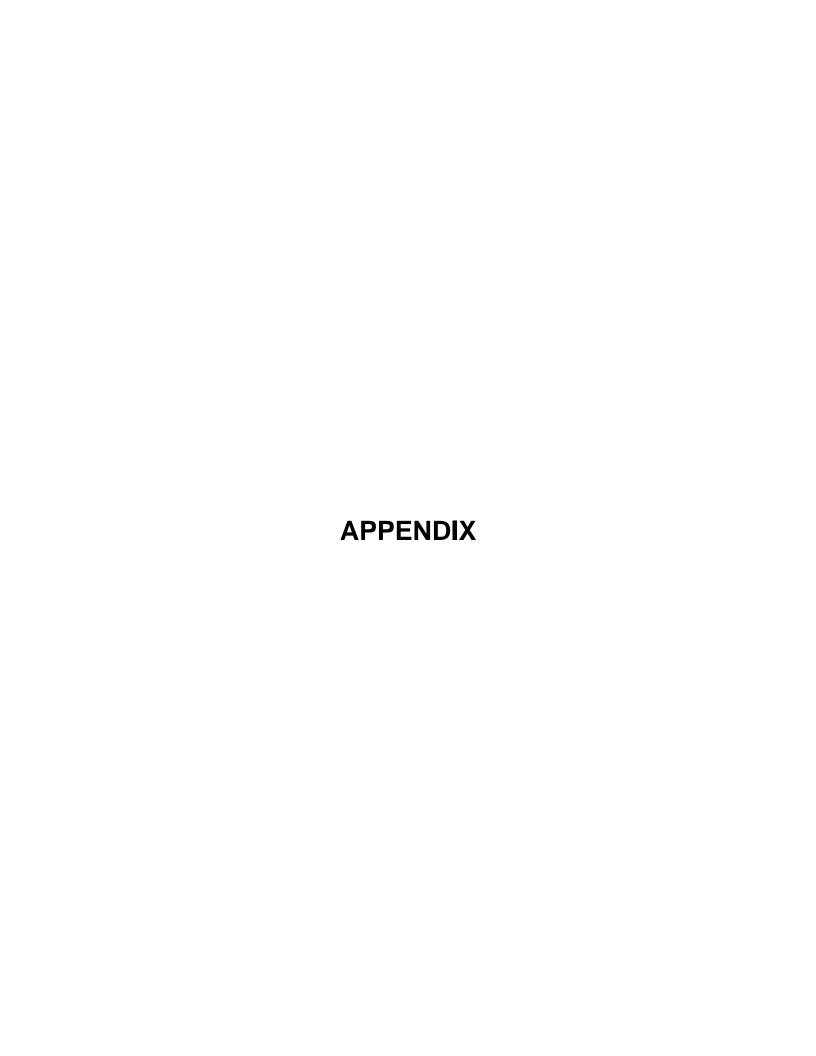
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APPENDIX

D&D Focus Area			OST Technology ID		
Priority Score	Need ID	Need Title	148	2173	2199
2	AL-00-01-07-DD	Ex Situ Glove Box Size Reduction System			1
2	ID-7.2.08	Robotics for D & D		1	
2	ID-7.2.11	Asbestos Wrapped/Insulated Pipe Removal and Packaging.	1		
2	OH-M010	Tritium Robotics		1	
3	OH-WV-909	Remote Handled Waste Processing		1	
3	RF-DD21	Removal of Pb Shielding from Gloveboxes and other Process Equipment			1
2	RL-DD010	Radiation Hardened Robotics for Building 324		1	
3	RL-DD02	Glove Box Size Reduction System for PFP			1
3	RL-DD061	Remote Systems for Characterization and Clean-Up of the 233-S Process Hood		1	
1	SR00-2031	Develop Remote Technology to Improve DWPF Operations		1	

	D&D Focus Area					
OST Technology No.	Technology Title	Cost to Date	Total Projected Cost	Earliest Date Needed	Latest Date Needed	Date Available
148	Asbestos Pipe-Insulation Removal System	$2,360,743.00	$3,000,000.00	1999	2000	2000
2173	Dual-Point Impedance Control for Telerobotics	$664,879.00	$1,200,000.00	1999	2001	2000
2199	Modular Manipulator for Robotic Applications	$1,521,633.00	$2,500,000.00	2002	2004	2002

TRU & Mixed Waste Focus Area			OST Technology ID												
Priority Score	Need ID	Need Title	106	1447	1564	1664	2021	2041	2052	2053	2146	2170	2226	2305	2979
3	ID-3.1.32	Develop Nondestructive Assay (NDA) Capability for Remote-Handled TRU Waste and Contact-Handled TRU Waste with Shielded RH Components								1					
3	ID-S.1.05	Nondestructive Assay (NDA) Capability for Remote-Handled Transuranic Waste								1					
3	AL-09-01-24-MW-S	Radioassay of Remote-Handled Transuranic (RH-TRU) Waste Containers to Meet WIPP Data Quality								1					
2	AL-07-01-07-MW	Treatment of Mixed Waste Contaminated with Mercury						1							
1	AL-07-01-11-MW	Waste Sorting and Characterization				1									
2	AL-07-01-14-MW	Appropriate Characterization of TRU Waste Now Stored in Fiberglass Reinforced Plywood Boxes for Waste Isolation Pilot Project (WIPP)				1									
1	AL-07-02-06-MW	Characterization of Excess Legacy Material - Reactor Experiments							1						
1	AL-08-01-17-MW	Certifiability of Newly Generated TRU Waste	1												
1	AL-09-01-06-MW	Mobile Neutron Assay System (Mn/aS) for SWBs										1			
3	AL-09-01-09-MW	Integrated Systems Approach to the Destruction and Treatment of Both Solid and Liquid Combustible Pu-238 Contaminated Waste	1												

TRU & Mixed Waste Focus Area			OST Technology ID												
Priority Score	Need ID	Need Title	106	1447	1564	1664	2021	2041	2052	2053	2146	2170	2226	2305	2979
2	AL-09-01-10-MW	Integrated Systems Approach to the Destruction and Treatment of Both Solid and Liquid Combustible Pu-239 Contaminated Waste	1												
3	AL-09-01-17-MW	Robust Hydrogen Getters for TRU Waste					1								
3	AL-09-01-24-MW-S	Radioassay of Remote-Handled Transuranic (RH-TRU) Waste Containers to Meet WIPP Data Quality							1						
3	AL-09-01-25-MW-S	Radioassay of Very Large Containers of Low-Level Contact-Handled Transuranic (CH-TRU) Waste to Meet WIPP Data Quality Assurance Objectives									1				
3	CAO-00-09	Development of Automated Systems That Support Remote Handled TRU waste				1									
2	CAO-99-02	Mobile RH-TRU Waste Handling System				1									
1	CAO-99-04	Sampling and Characterization of Remote-Handled Wastes							1						
2	CH-MW02-99	Treatment of PCB-Contaminated Low Level Radioactive Waste	1												
2	CH-MW04-99	Treatment of PCB Contaminated Low Level Waste	1												
2	CH-MW05-99	Treatment of PCB Contaminated Low Level Waste	1												
3	ID-3.1.32	Develop Nondestructive Assay (NDA) Capability for Remote-Handled TRU Waste and Contact-Handled TRU Waste with Shielded RH Components							1						
3	ID-3.1.33	Develop In-Situ Hydrogen and Volatile Organic Compound (VOC) Reduction					1								
3	ID-3.1.48	WERF Polychlorinated Dibenzofuran Control for MACT Compliance												1	
2	ID-3.2.32	Develop Thermal Treatment Unit Offgas CEM Monitors.										1		1	
3	ID-S.1.02	Continuous Emissions Monitors for Offgas Analysis			1							1			
3	ID-S.1.03	Efficient and Safe Hydrogen Gas Getters for the Reduction of Hydrogen Gas in TRU Waste Containers					1								
3	ID-S.1.05	Nondestructive Assay (NDA) Capability for Remote-Handled Transuranic Waste							1						
2	OH-AB-003	Thermal Destruction with Molten Salt Oxidation (MSO)	1												

TRU & Mixed Waste Focus Area			OST Technology ID												
Priority Score	Need ID	Need Title	106	1447	1564	1664	2021	2041	2052	2053	2146	2170	2226	2305	2979
2	OH-AB-005	Electro-Thermal Plasma Treatment of Solids	1												
2	OH-AB-010	PCB Treatment Technologies	1												
2	OH-AB-014	Molten Salt Oxidation Technology	1												
2	OH-WV-901	Characterization of Low-Level Transuranic Waste (WVDP-1-99)							1		1				
3	OK99-06	Mobile Non-Destructive Assay for TRU Waste Boxes									1				
3	OK99-09	Destruction of Mixed Chlorinated Solvents	1												
3	RL-MW013	Non-Destructive Assay (NDA) of RH TRUW (High Beta/Gamma Field) to Meet WIPP Requirements							1						
3	RL-MW026	Getter for Hydrogen					1								
2	RL-MW05	Remote Treatment of RH Soils and Other Solid Wastes Contaminated With Organics.	1												
2	RL-MW06	Treatment of CH TRUW Liquid Wastes Contaminated With PCBs and Ignitables.	1												
1	RL-MW07-S	Non-Intrusive, Non-Destructive Characterization Methods for Non-Radionuclide Hazardous Chemical Components of Mixed Low-Level Waste.											1		
3	SR00-1001	Technologies to Increase Transuranic Waste Transportation System Curie, Size, and Weight Limits					1								
3	SR00-1002	Treatment for MW Soils to Immobilize Radionuclides and RCRA Constituents for Disposal	1												
2	SR00-1003	Improvements to Physical, Chemical, and Radionuclide Quantification of Solid Waste									1				
3	SR00-1004	Need for Continuous Emissions Monitors for Measurement of Hazardous Compound Concentrations in Incinerator Stack Gas										1		1	
3	SR00-1007	Treatment of High Activity TRU (Pu238) Waste for Destruction of Organic Constituents	1												
3	SR00-1021	Need to Reduce the Dioxin and Furan Emissions from the CIF												1	

OST No.	Title	Cost to Date	Total Projected Cost	Earliest Date Needed	Latest Date Needed	Date Available
	TRU & Mixed Waste Focus Area					
106	Catalytic Chemical Oxidation-Delphi Detox	$14,162,917.00	$20,000,000.00	1999	2002	2002
1447	Self Assembled Monolayers on Mesoporous Supports for RCRA Metal Removal	$902,000.00	$1,000,000.00	2001	2002	2001
1564	Compact Resolution Spectrometer	$770,000.00	$1,500,000.00	2000	2002	2001
1664	Mechanical Systems - Handling Material in CH Processes using HANDSS-55 Systems	$3,466,000.00	$9,500,000.00	2003	2005	2005
2021	Hydrogen Gas Getters	$1,061,000.00	$3,000,000.00	2002	2003	2002
2041	Mercury Contamination - Separate and Remove Mercury Using Polymer Filtration	$750,000.00	$1,050,000.00	2001	2004	2001
2052	Characterization of RH Waste Drums using Multi-Detector Assay System	$1,204,000.00	$2,500,000.00	2001	2002	2002
2053	Characterization of Remote-Handled Waste Drums Using Gamma Spectrometry Combined with Acceptable Knowledge	$409,000.00	$900,000.00	2001	2002	2002
2146	Nondestructive Assay of Boxes Containing Transuranic Waste	$1,517,000.00	$1,900,000.00	2002	2002	2002
2170	Surface Acoustic Wave Mercury Vapor Sensor	$2,149,792.00	$3,150,000.00	2001	2002	2001
2226	Pulsed Gamma Neutron Activation Analysis System for the Assay of RCRA Metals in Mixed Waste	$2,228,672.00	$2,229,000.00	2002	2003	2001
2305	Continuous Emissions Monitor for Dioxins	$1,230,657.00	$3,300,000.00	2001	2003	2002
2979	Composite Hydrogen Getter Materials	$271,000.00	$800,000.00	2002	2005	2002

Priority Score	Need ID	Need Title	307	2061	2186	2193
		Subsurface Contaminants Focus Area		OST Technology ID		
2	AL-08-01-16-SC	Cost Effective Technologies for Addressing TRU in Soils and Sediments			1	1
3	OK00-04	Removal of Subsurface VOC Contaminants in Low Permeability Soil Intermixed with Fractured Rock		1		1
2	OK00-24	Technology for Groundwater and Soil Cleanup in Fractured Rock		1		1
3	RF-ER14	Characterization/Detection/Verification of Non-Aqueous Phase Liquids (NAPLs)	1			1
3	RL-SS17	Long-Life Waste Isolation Surface Barrier			1	1
1	RL-WT017	Long-Term Testing of Surface Barrier			1	1
2	SR00-7001	Long-Term Cover System for a Humid Environment			1	1

OST No.	Title	Cost to Date	Total Projected Cost	Earliest Date Needed	Latest Date Needed	Date Available
	Subsurface Contaminants Focus Area					
307	In Situ Permeability Measurements with Direct Push Techniques	$368,066.00	$700,000.00	2000	2004	1999
2186	Long-term Surface Barriers	$4,000,000.00	$7,000,000.00	2005	2008	2006

Priority Score	Need ID	Need Title	New	206	841	1989	2119	2367	2943	2967	2968
	Tanks Focus Area				OST Technology ID						
3	ID-2.1.06	TRU, Cs and Sr Removal from High Activity Wastes			1						1
3	ID-2.1.06a	TRU and Sr Removal from High Activity Waste			1						1
3	ID-2.1.06b	Cs Removal from High Activity Waste			1						1
3	ID-2.1.23	Low-Activity Wasteform Qualification									
3	ID-2.1.26	Direct Tank Sampler for Tank Solution Characterization					1				
3	ID-2.1.28	Cs and Sr Removal from Newly Generated Liquid Waste									
3	ID-2.1.35	Direct Immobilization of INTEC Sodium-Bearing and Newly Generated Liquid Wastes									
3	ID-2.1.38	Conditioning of Low Activity Waste for Treatment									
3	ID-2.1.40	Low Activity Waste Grout Sorbent Addition to Reduce Leachability									
3	ID-2.1.43	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Liquids					1				

Tanks Focus Area			OST Technology ID								
Priority Score	Need ID	Need Title	New	206	841	1989	2119	2367	2943	2967	2968
3	ID-2.1.44	Certify LDUA Sampler as EPA-Approved Method of Sampling Tank Heel Solids					1				
3	ID-2.1.56	Mercury Treatment for Aluminum Calcine			1						1
3	ID-2.1.57	Conditioning of HAW for Treatment									
3	ID-2.1.58	HAW Immobilization									
3	ID-2.1.66	Treatment/Disposition of Spent Ion Exchange Resins									
3	ID-2.1.68	Technetium Removal from INEEL High Level Waste				1					1
3	ORTK-02	Tank Solid Waste Retrieval				1					
3	ORTK-04	Sludge Mixing and Slurry Transport				1				1	
3	ORTK-05	Tank Sludge and Supernatant Separations				1				1	
3	ORTK-06	Tank Sludge and Supernatant Immobilization									
2	RL-WT013	Establish Retrieval Performance Evaluation Criteria				1					
2	RL-WT015	Standard Method for Determining Waste Form Release Rate									
2	RL-WT023	Prediction of Solid Phase Formation in Static and Dynamic Hanford Tank Waste Solutions				1		1		1	
3	RL-WT024	Enhanced Sludge Washing Process Data				1				1	
3	RL-WT027	Tank Leak Mitigation Systems				1					
2	RL-WT037-S	Sludge Treatment				1				1	
2	RL-WT038-S	Process Models for Sludge Treatment				1				1	
2	RL-WT040-S	Mechanisms of Line Plugging				1		1		1	
1	RL-WT049-S	Effect of Processing on Waste Rheological and Sedimentation Properties				1				1	
2	RL-WT060	PHMC Retrieval and Closure - Hanford/SRS Waste Mixing Mobilization				1				1	
2	RL-WT063	PHMC Retrieval and Closure - Hanford SST Saltcake Dissolution Retrieval				1				1	
2	RL-WT064	PHMC Retrieval and Closure - Hanford Past Practice Sluicing Improvements				1				1	
2	RL-WT066	Compositional Dependence of the Long Term Performance of Glass as a Low-Activity Waste Form									
3	RL-WT070	Uncertainty Estimation of Hanford Best Basis Toxic Waste Inventory, Concentration, Phase and Waste Type				1				1	
3	RL-WT071	Provide Laboratory Development Support and ESP Modeling Support for the Back Dilution of Tank 241-SY-101				1				1	
3	RL-WT075-S	HLW Solid Phase Characterization				1				1	
2	RL-WT077-S	Improvements to Salt Well Pumping				1					
2	RL-WT078-S	Plutonium Segregation and Association in HLW				1				1	
2	RL-WT080	Advanced/Improved Vitrification									
2	RL-WT081	Sulfate Accumulation in Low Activity Waste									
3	RL-WT09	Representative Sampling and Associated Analysis to Support Operations and Disposal					1				
2	SR00-2028	Alternative Waste Removal Technology				1				1	
2	SR00-2032	Optimize Melter Glass Chemistry and Increase Waste Loading									
2	SR00-2033	Provide Alternative Processing and/or Concentration Methods for DWPF Recycle Aqueous Streams									
1	SR00-2036	Develop Improved HLW Melter									
3	SR00-2037	Tank Heel Removal/Closure Technology				1				1	
2	SR00-2039	Methods to Unplug Waste Transfer Lines				1		1		1	
2	SR00-2052	Aluminum Dissolution from HAW Sludge and its Impact on Downstream Salt Processing				1				1	

Tanks Focus Area						
TITLE	OST No.	Cost to Date	Total Projected Cost	Earliest Date Needed	Latest Date Needed	Date Available
Advanced Vitrification System	New	TBD	TBD	no links	no links	no links
	82	$7,789,000.00	$16,264,000.00	2003	2010	2002
INEEL HLW Processing	206	$6,024,000.00	$6,524,000.00	2001	2001	2002
Russian Separations-Cobalt Dicarbollide	841	$1,229,000.00	$3,629,000.00	2012	2012	2012
SaltCake Dissolution	1989	$1,325,000.00	$3,700,000.00	2005	2007	2005
	2009	$5,450,000.00	$8,500,000.00	2000	2002	2000
	2091	$925,000.00	$2,500,000.00	2000	2002	2001
Nested Fixed Depth Fluidic Sampler	2119	$2,190,000.00	$3,000,000.00	2004	2012	2001
Pipe Unplugging	2367	$2,056,000.00	$4,000,000.00	1999	2002	2001
Remote Technologies for High Level Waste Tank Component Maintenance and Disposal	2943	$700,000.00	$1,500,000.00	no links	no links	2003
Chemical Cleaning	2967	$100,000.00	$600,000.00	1999	2003	2000
Cesium Removal Using AMP-AN	2968	$700,000.00	$3,200,000.00	2004	2020	2002

NMFA Needs			OST Technology ID																	
Priority Score	Need ID	Need Title	2343	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	RL-99-004-NM	Process Optimization – Extension of Plutonium Precipitation Process for Hanford's Plutonium Finishing Plant (PFP)	1			1														
2	RL-00-005	Long Term Gas Generation Surveillance										1	1							
2	RL-00-007	Dynamic Simulation of Process Logistics for all 94-1 Activities				1														
2	RL-00-008-NM	Coverage of Miscellaneous Small Categories of Materials Without a Defined Disposition Path	1			1														
3	RL-00-011-NM	Furnace Time Cycle Improvement - Pu Finishing Plant			1															
3	AL-00-01-17-NM-S	Modeling of Gas Generation During Storage and Shipment							1	1	1									
3	AL-09-01-27-NM	Gas Generation Measurements for Nuclear Material Shipping Environments							1	1	1		1							
3	AL-09-01-38-NM	Moisture Analytical Methods for Nuclear Materials										1	1							
3	AL-09-01-39-NM	Nuclear Materials Stabilization Development														1	1			
3	AL-09-01-41-NM	Conversion of Classified Shapes																		
3	AL-09-01-46-NM	Development of Automated Systems That Support Plutonium and Other Nuclear Materials Processing and Handling		1																
3	OAK-99-002-NM	Decontamination of >5 ppm Plutonium Contaminated Uranium and Non-SNM Materials Allowing Utilization of Paths Other than Materials Disposition					1							1	1	1	1			
3	OAK-99-003	Concentrating Pu in 20-30 wt% Pu residues to allow disposition by the Fissile Material Disposition Program				1														
3	OAK-99-004-NM	Physical Process Modeling of Gas Generation in Plutonium Storage Containers							1	1	1									
3	OH-F045	Investigate Processing and/or Transportation of Problem Materials		1					1											
2	OH-F046	Vacuum Transfer System																		
3	RF-SNM13	RFETS Residue and Misc. TRU Waste Stabilization Process Support																		
3	RF-SNM14	Moisture Analytical Methods for Plutonium Materials										1	1							
3	RF-SNM17	Gas Generation Measurements for NM Shipping Environments							1	1	1		1							
3	SR00-5017	Impact of Radiolysis Gas on Sealed Storage Containers							1											
3	SR00-5018	Gas Generation During Shipping and Storage of Residue Materials							1	1	1		1							

NMFA Needs			OST Technology ID																	
Priority Score	Need ID	Need Title	2343	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
2	SR-00-5019	Prevention of the Precipitation of Unwanted Solids During Canyon Dissolution						1												
2	SR00-5022	High Enriched Uranium - Molybdenum Fuel Reprocessing Technology and Development					1							1	1	1	1			
2	SR00-5023	Actinide Ceramic Formation for Excess Pu and other Nuclear Materials Encapsulation				1														
3	SR00-5025	Impact on Safe Storage and Shipping										1	1							

Nuclear Materials Focus Area		Cost to Date $K	Total Projected Cost $K	Earliest Date Needed	Latest Date Needed	Date Available
OST No.	Title					
2343	Porous Crystalline Matrix	500	1000	Sep-00	?	?
2	Automatic Packaging of Nuclear Material	0	750	Sep-00	?	Sep-02
3	Plutonium thermal Treatment Furnace Load-out System	0	634	Sep-00	?	Jun-03
4	Optimal Plutonium Precipitation for Stabilization Feed Preparation	0	500	Feb-00	?	Dec-04
5	Dissolution and Stabilization of Plutonium Using Thermally Unstable Complexants	0	720	Oct-98	?	Mar-04
6	Prevention of the Precipitation of Unwanted Solids During Canyon Dissolution	0	168	Sep-00	?	Sep-01
7	Advanced Modeling and Experimantal Validation of Complex Nuclear Material Waste Forms of Potential Transportation Concern	0	1450	Sep-00	?	Jun-04
8	Modeling Gas generation from Radiolysis of Adsorbed Water on Plutonium Dioxide	0	680	Sep-00	?	Jun-02
9	3CEJ Alpha Radiolysis Studies for U-233 Oxides	0	501	Sep-00	?	Jun-02
10	Relative Humidity: A Practical Measurement of Material Moisture Content	0	1130	Sep-00	?	Sep-04
11	Implementation of Moisture Measurement Technology for Nuclear Materials Stabilization	0	931	Sep-00	?	Jun-03
12	Removal of Plutonium Contamination from Uranium Metal Surface	0	5150	Sep-00	?	Sep-04
13	Decontamination of Uranium Parts Using Laser Ablation	0	1916	Sep-00	?	Sep-04
14	Removal of Plutonium Contamination	0	2000	Sep-00	?	Sep-00
15	Verification of Plutonium Removal from Uranium	0	1120	Sep-00	?	Jun-04